EPA Comments

SUBJECT: Comments on "DRAFT REPORT - Dam Safety Assessment of CCW Impoundments: TVA Allen Fossil Plant"

DATE: August 30, 2012

COMMENTS:

1. On page iii, second paragraph of the "**PURPOSE AND SCOPE**" on that page, remove the reference to Appendix C at the end of the paragraph.
2. On page 1-2, Section 1.1.2 "Conclusions Regarding the Hydrologic/Hydraulic Safety of the Management Unit(s)," it would be advantageous for the report to identify the greater frequency storm events, i.e., 25 year/24-hour, 10 year/24-hour, and the expected performance of the units under these design storm events. Although passing a PMP event implicitly means the units will pass higher frequency storms, it would be advantageous to explicitly state the unit passes the design events.
3. In Section 1.1.3, the report should state that the West Ash Pond has not been formally closed and has not been breached, if this is the case.
4. In section 2.5.1 "Earth Embankment," the report details that the south side crest accommodates a railroad siding. It would be advantages for the report to address the issue and whether EPA contractor feels that the effect of the added loading on the south crest warrants further consideration by EPA, if the additional loading has been considered in geotechnical studies, or if there is no cause for additional concern. Additionally, there should be additional information regarding the railroad siding, such as rail use, whether rail cars are typically parked for extended periods on the embankment, volume of traffic on the railroad siding, etc.
5. In section 4.1.2 "Significant Repairs/Rehabilitation since Original Construction," it is made apparent from the report, in addition to the attached Stantec "Plan View 1," that there are major sewer lines running through or under the CCR impoundment. The report must elaborate on this sewer line more than in the draft report. The contractor should give their engineering opinion on the risk posed by damage to the sewer lines subtending the embankments of the impoundments. Since there was recent damage discovered to the 30" line that caused slumping in the dredge cell, a construction history of the sewer line would be advisable, if available. Additionally, the location of the sewer line with regard to the embankments should be noted, i.e., depth from grade or approximate base of impoundment. The report should not if the condition of the sewer lines is known, including potential for additional rupture in the future. If there is any special casing around the sewer line, the report should note such. Potential for settlement of the line, if known, should be noted.

Stantec Consulting Services Inc.
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October 11, 2012 let_009_175551015_rev_1

Mr. John C. Kammeyer, PE
Vice President
Tennessee Valley Authority
1101 Market Street, LP 5G
Chattanooga, Tennessee 37402

Re: Response to Recommendations
USEPA CCR Impoundment Assessment DRAFT Report
Allen Fossil Plant (ALF)
Memphis, Tennessee

Dear Mr. Kammeyer:

As requested, Stantec has reviewed the DRAFT report *Coal Combustion Residue Impoundment Dam Assessment Report, Allen Fossil Plant, Tennessee Valley Authority, Memphis, Tennessee,* dated August 2012 prepared by Dewberry and Davis, LLC (Dewberry) for the United States Environmental Protection Agency (USEPA). The purpose of this letter is to address Dewberry's conclusions and recommendations pertaining to structural stability, hydrologic/hydraulic capacity, and technical documentation; and to provide additional supporting information relative to ongoing plant improvements, further analysis, and planned activities where applicable. Dewberry's recommendations followed by Stantec's corresponding responses are provided below.

Dewberry Report Section 1.2.3 1) – East Ash Pond: *Perform appropriate seismic stability analyses that use the USEPA design earthquake criterion for Significant hazard impoundments (i.e., earthquake with 2,475-year return period). Provide the basis and reasoning for the "design" seismic coefficient used in further pseudostatic slope stability analysis or perform a higher level of analysis that uses more sophisticated methods.*

Response: Refer to attached letter containing results of seismic analysis provided by Geocomp Consulting, Inc.

Dewberry Report Section 1.2.3 2) – East Ash Pond: *Review/evaluate liquefaction potential and, if necessary, perform a quantitative liquefaction analysis.*

Response: Refer to attached letter containing results of liquefaction analysis provided by Geocomp.

Dewberry Report Section 1.2.3 3) – East Ash Pond: *If it is determined that liquefaction is not likely, review/investigate the very soft to soft soils in the alluvial foundation beneath the dike embankments, evaluate deformation potential during the design earthquake, and assess the impact of any such deformation on the stability of the embankment.*

Response: Geocomp's analysis indicates that liquefaction will occur; therefore, they performed a post-earthquake stability analysis. Their results produced a factor of safety greater than the target value of 1.0**.** For additional information, please refer to the attached letter containing description of seismic analysis performed by Geocomp Consulting, Inc.

Dewberry Report Section 1.2.3 - Last Paragraph – West Ash Pond: *If future plans call for re-activating the West Ash Pond, perform all required engineering analyses and develop all necessary technical documentation to demonstrate its ability for continued safe and reliable operation before it is brought back into service.*

Response: TVA does not presently intend to reactivate ash sluicing to the West Ash Pond, and management of the minor, low volume wastewater streams currently routed to the pond does not result in discharge from the pond. Consequently, no additional analysis is deemed necessary.

Dewberry Report Section 1.2.5 – Maintenance Items:

1) *Repair gully erosion on the divider dike;*
2) *Add crushed stone surfacing material in worn shallow depression on the dike crest south side where haul trucks turn into the dredge cell;*
3) *Avoid mowing the slopes when the ground is still wet from rainfall to minimize mower ruts on the slopes;*
4) *Observe over time the wet area at the toe of the north side exterior slope to verify that the puddle is not due to seepage. If the water source is found to be seepage, then repair the slope with an inverted filter. If the water is not from seepage, then re-grade or fill the slight depression with crushed stone surfacing material.*
5) *Paint corroded metal parts and hardware at the spillway in the divider dike and on the gates and gate-operators at the discharge end of the primary outlet conduits.*

Response:

1) TVA has repaired the previously eroded area by installing riprap.
2) TVA has repaired this dike crest area by placing 4 inches of asphalt pavement.
3) TVA's mowing crews have been advised not to mow slopes when the ground is wet.

4) TVA has monitored the area and has concluded that the area is not exhibiting seepage. Additionally, the area has been regraded and also covered with crushed stone for additional protection.
5) TVA plans to paint the corroded materials within the next 30 days.

Based on the responses provided in this letter and on Geocomp's seismic analysis indicating acceptable performance under seismic loading, it is Stantec's opinion that the final rating for the ALF East Ash Pond should be upgraded to Satisfactory.

We appreciate the opportunity to provide these responses. If you have any questions or need additional information, please call.

Sincerely,

STANTEC CONSULTING SERVICES INC.

Stephen H. Bickel
Stephen H. Bickel, PE
Senior Principal

Randy L. Roberts
Randy L. Roberts, PE
Principal

/cdm

Cc: Roberto L. Sanchez, PE
Michael S. Turnbow

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October 10, 2012 let_20329-01

Mr. John C. Kammeyer
Vice President
Tennessee Valley Authority
1101 Market Street, LP 5G
Chattanooga, Tennessee 37402

Re: USEPA CCR Impoundment Assessment DRAFT Report
Allen Fossil Plant (ALF)
Memphis, Tennessee

Dear Mr. Kammeyer:

As requested, Geocomp Consulting, Inc has evaluated the seismic response of a representative cross section of the East Ash Pond in response to comments raised in the DRAFT report *Coal Combustion Residue Impoundment Dam Assessment Report, Allen Fossil Plant, Tennessee Valley Authority, Memphis, Tennessee,* dated September 2012 prepared by Dewberry and Davis, LLC (Dewberry) for the United States Environmental Protection Agency (USEPA). The purpose of this letter is to provide a summary of results obtained from additional investigations and analyses to assess the likely performance of this facility to the design earthquake. We have performed this work with the assistance of Professor Steve Kramer, a well-known expert in earthquake engineering, from the University of Washington.

Location and conditions

The Allen Fossil Plant is located at 2574 Steam Plant Road in the town of Memphis, Shelby County, Tennessee. The plant is situated on the south shore of Lake McKellar and on the eastern bank of the Mississippi River, approximately 5 miles southwest of Memphis, Tennessee. The existing impoundment facilities at the Allen Fossil Plant consist of two ash disposal areas; one inactive ash disposal area to the west of the centrally located power plant and one active ash disposal area to the east of the centrally located power plant.

Consistent with previously submitted seismic analysis, cross section B-B' along the northern perimeter dike system of the east active ash disposal area was analyzed. Please refer to Figure 1 for an aerial image of the east active ash disposal area facility layout as well as the location of cross section B-B'.

Approach

Appendix 1 summarizes the approach taken to assess the likely performance of the East Ash Pond for the design earthquake, which is taken as that with a recurrence interval of 2,500 years. The approach consists of the following steps:

- Additional site investigation consisting of borings for SPT testing and recovery of undisturbed samples of cohesive soils, cone penetration test soundings with shear wave velocity measurements, and field vane tests to the extent that site conditions would allow.
- Installation of two strings of permanent piezometers to measure the pore water pressure distribution within the cross-section.
- Laboratory testing to determine basic soil parameters and the undrained shear strength of cohesive soils.
- Development of representative cross section with soil parameters and pore water pressures.
- Stability analyses to determine the minimum factor of safety with no earthquake forces present.
- Stability analyses to determine the minimum factor of safety for average horizontal acceleration values from 0 to 0.5 using soil strengths modified to account for reduction of static strength by cyclic loading.
- Dynamic analyses to determine the representative average horizontal acceleration value for the cross section using site specific input accelerations and subsurface conditions.
- Determine the pseudostatic factor of safety for stability failure.
- Dynamic analyses to compute the potential displacements that might occur assuming that liquefaction does not occur.
- Determine extent of liquefaction, if any, and its potential consequences.

Site Conditions

Figure 2 provides the cross section details developed from the existing information and the additional information obtained during the supplemental site investigation program. A significant result from the field investigation was the determination that pore pressures are significantly less than hydrostatic throughout the cross section. This means that effective stresses are higher and correspondingly soil strengths are higher than what is obtained if pore pressures are assumed to be hydrostatic below the top phreatic surface.

Figure 2 also includes a table that summarizes the soil strength parameters. A major effort was devoted to determining soil strength parameters with current state-of-practice methods. SPT testing was done under the observation of a geotechnical engineer or geologist to help ensure that all test conditions met the requirements of ASTM D1586. Cone penetration testing with shear wave velocity measurements was done to help define the layering and strength characteristics of the various soil layers. Field vane tests were run to measure in situ shear strength. Laboratory tests were run to determine undrained shear strength of cohesive strengths. Results of a laboratory test program on fly ash done by GEI Consultants were used to set the strength parameters for fly ash. Table A-2 summarizes the approach used to define strength parameters for the various materials and analysis methods.

Ground motions and cyclic shear stresses were determined from site-specific response analyses. A suite of seven spectrum-compatible, hard-rock motions provided by AMEC Geomatrix were propagated upward from bedrock at a depth of 2,800 ft through a one-dimensional soil profile to the ground surface. The ground motions at a depth of 138 ft below the crest of the embankment were extracted from these analyses and used as input motions to two different two-dimensional finite element models of Section B. One set of analyses, using the nonlinear computer program, OpenSees, allowed direct modeling of the permanent deformations of the profile under earthquake loading conditions. The other set, performed using the equivalent linear program, Quad4M, produced dynamic motions from which the average acceleration history of the potentially unstable soil could be evaluated. Those average acceleration histories where then used in Newmark sliding block analyses to provide an additional estimate of permanent deformations of the profile.

Results

Section B-B' has a factor of safety against a global stability failure of 2.8 for current conditions. The yield acceleration for this section is 0.185g. The critical failure surface at this yield acceleration is shown in Figure 3.

Peak average horizontal accelerations for this cross section as determined from the Quad4M analyses ranged from 0.210g to 0.339g with an average of 0.259g. This means the yield acceleration for the slope would be momentarily exceeded by the average horizontal acceleration, which would result in some permanent deformation of the slope. If the yield acceleration is exceeded only for several short intervals of time, the permanent displacements can be quite small.

The nonlinear OpenSees analyses produced maximum permanent displacements ranged from 1.9 in to 3.7 in with an average of 2.3 inches. Newmark sliding block type displacement analyses using the yield acceleration from the pseudostatic stability analysis gave estimated permanent displacements ranging from 0.1 in to 1.2 in with an average of 0.7 inch. Thus, two independent approaches to the estimation of permanent deformations both showed that such deformations can be expected to be quite small – on the order of only a few inches.

Calculations to determine the factor of safety against liquefaction versus depth were made using the Youd et al (2001) recommendations to determine cyclic resistance ratio. Cyclic stress ratio was determined from the dynamic analyses described above. Tables 2 and 3 summarize the calculations and results to determine potential for liquefaction for the two new borings performed as part of this evaluation. Blow count data from prior borings were not used in this valuation because for reasons not yet understood, they gave higher SPT values. We gave more credence to the latest borings that were done using cased holes filled with drilling mud under the constant monitoring by a geotechnical engineer or geologist. The native silty sand layers generally have low blow counts and liquefy. The strength of the fly ash is not a factor in the stability of this facility.

Since liquefaction may potentially occur for the design earthquake, the post-shaking stability of the slope comes into question. This was examined with stability analyses for static conditions but with reduced shear strengths. The pseudo-static strength values were used for all soils that do not liquefy. The residual shear strengths computed by the method of Idriss and Boulanger (2007) were used for the soils that may potentially liquefy. The computed residual strength values are given in Table 2 and 3 as well. Figure 4 shows the results of the post-shaking stability analysis. The factor of safety is 1.1 which is an acceptable value for this condition. The critical surface drops into the native silty sand layer that has relatively low blow counts.

Conclusions and Recommendations

The results show that the East Ash Pond at the Allen Fossil Plant has adequate safety for the design basis earthquake. While some of the soils, the native silty sands, have factors of safety against liquefaction that are less than 1, the representative cross section has sufficient strength to resist a shear slide even with soil strengths reduced for repeated loading and liquefaction.

Sincerely yours,

W. Allen Marr

W. Allen Marr, PE, PhD, NAE
Chief Executive Officer

Steven L. Kramer

Steven Kramer, PhD
Professor, University of Washington

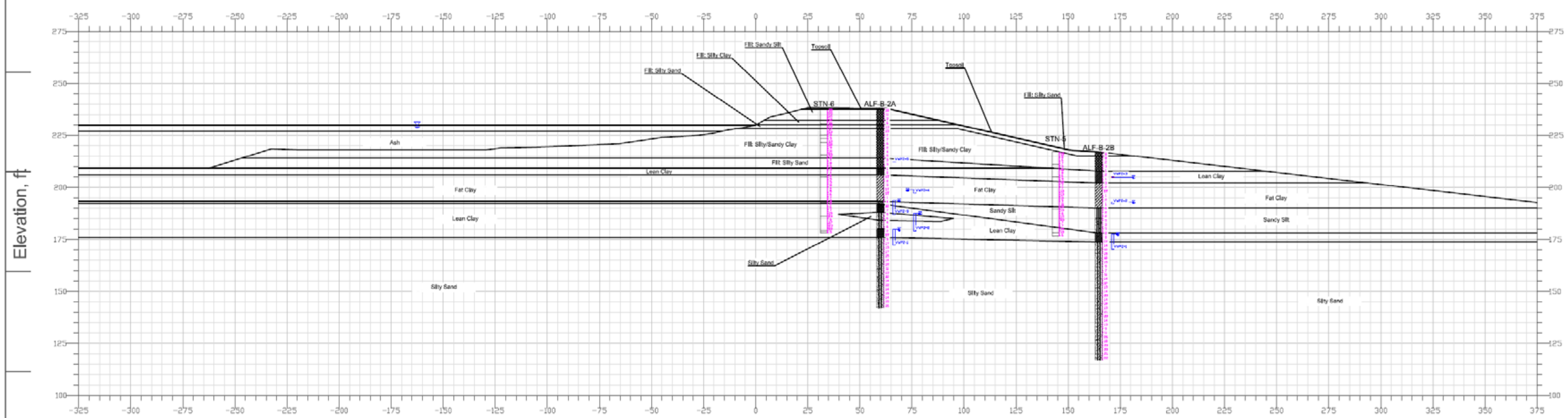
Figure 1: Site Layout for Allen Fossil Plant

Geocomp Borehole Locations†		
Borehole ID	**Northing**	**Easting**
ALF-B-2A	35.07371 deg	-90.13454 deg
ALF-B-2B	35.07402 deg	-90.13445 deg

Stantec Borehole Locations		
Borehole ID	**Northing**	**Easting**
STN-6	274264.03 ft	763177.15 ft
STN-5	274366.34 ft	763200.60 ft

Notes:
1. DEPICTION OF SOIL PROFILE BETWEEN EXPLORATION HOLES IS FOR ILLUSTRATION OF POSSIBLE GEOLOGICAL CONTINUITY, ACTUAL CONDITIONS WILL MOST LIKELY BE DIFFERENT.
2. SURFACE CONTOUR IS DEPICTED BASED ON DRAWING PROVIDED BY TVA TITLED "EAST ASH POND - USACE LEVEE".
3. DEPICTION OF THE SUBSURFACE SOIL PROFILE GEOMETRY IS BASED ON 2012 SUBSURFACE INVESTIGATION CONDUCTED BY GEOCOMP CORPORATION, INC.
4. UNCORRECTED SPT N-VALUES ARE PRESENTED.
5. *BOREHOLE INVESTIGATIONS CONDUCTED BY STANTEC ARE DEPICTED FOR COMPARATIVE PURPOSES. NO WARRANTIES CAN BE MADE REGARDING THE ACCURACY OF THEIR DATA, HORIZONTAL LOCATION OF BOREHOLE HAS BEEN ADJUSTED FOR VISUAL CLARITY. SURFACE ELEVATION OF STANTEC BOREHOLES IS ACCURATELY DEPICTED. REFER TO TABLE FOR EXACT NORTHING AND EASTING.
6. †NORTHING AND EASTINGS BASED ON CPT DATA

ALF Section B Soil Profile



Station, ft
Scale : As Shown

		STATIC					PSEUDOSTATIC				Post-Shaking		
		Drained		Undrained		Reduction	Drained		Undrained		Drained		Undrained
Soil	Type	c	φ'	Su			c	φ'	Su		c	φ'	Su
Fill - Sandy	U	0	30			100	0	30			0	30	
Fill - Sandy	S	0	30			80	0	25					
Fill - Silty Clay	U			2000		100			2000				2000
Fill - Silty Clay	S			2000		80			1600				1600
Fill - Silty Sand	U	0	30			100	0	30			0	30	
Fill - Silty Sand	S	0	30			80	0	25					245
Fill - Silty/Sandy Clay	U			2000		100			2000				2000
Fill - Silty/Sandy Clay	S			2000		80			1600				1600
Hyrdaulic Ash	S	0	30			80	0	25					c/p=0.06
Sandy Silt	S	0	25			80	0	20.5					225
Lean Clay	S			1200		80			1000				1000
Fat Clay	S			1200		80			1000				1000
Lean Clay (2)	S			1200		80			1000				1000
Silty Sand	S	0	35			100	0	35			0	35	
silty sand (2)	S	0	30			80	0	24.5					*

* Lower Silty Sand is modeled in several layers. For more information see the analysis cross section.

ALF-B-2A VWPZ Readings		
Piezometer ID	**Tip Elevation**	**Head**
ALF-B-2A-VWPZ-5	212.3 ft	0.0 ft
ALF-B-2A-VWPZ-4	197.3 ft	1.7 ft
ALF-B-2A-VWPZ-3	187.3 ft	6.7 ft
ALF-B-2A-VWPZ-2	179.3 ft	8.5 ft
ALF-B-2A-VWPZ-1	172.3 ft	7.8 ft

ALF-B-2B VWPZ Readings		
Piezometer ID	**Tip Elevation**	**Head**
ALF-B-2B-VWPZ-3	205.5 ft	-0.2 ft
ALF-B-2B-VWPZ-2	192.5 ft	0.9 ft
ALF-B-2B-VWPZ-1	170.5 ft	7.4 ft

ENGINEERS SEAL:

Tennessee Valley Authority
EPA Seismic Assessment
Oversight of Supplemental Site Exploration Program
Allen Fossil Plant - Section B Soil Profile

Geocomp Consulting, Inc.

REV. NO.	DATE	NATURE OF REVISION
1	28-AUG-2012	INCORPORATED STANTEC BH
0	13-AUG-2012	INITIAL DRAWING

DRAWN: MGD | CHECKED: VP | SUPERVISED: WAM
REVIEWED: WAM | APPROVED: VP | ISSUED: VP

AutoCAD CMI 3D 2012 | DATE: | DRAWING NUMBER: Section B - Soil Profile

Figure 2: Representative Cross Section for ALF East Ash Disposal Area

Tennessee Valley Authority
EPA Seismic Assessment
Project No. 20329
Oversight of Supplemental Site Exploration Program
Allen Fossil Plant - Memphis, TN

ALF Section B - Geocomp Soil Profile with Multiple Piezometric Lines - Pseudo-Static Analysis
10/02/2012

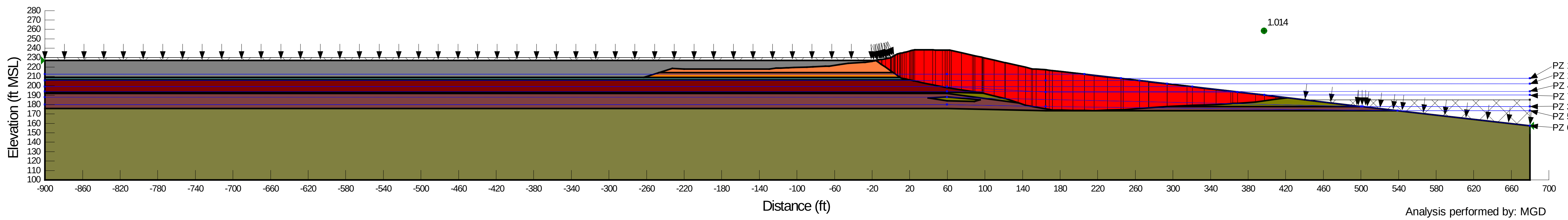
Material Properties

Material Type	Unit Weight	Cohesion	Friction Angle	PZ Line
Fill - Sandy Silt	125 pcf	0 psf	30°	1
Fill - Silty Clay	125 pcf	2000 psf	0°	1
Fill - Silty Sand	125 pcf	0 psf	25°	1
Fill - Silty/Sandy Clay	125 pcf	2000 psf	0°	1
Hydraulic Ash	105 pcf	0 psf	0°	1
Sandy Silt	125 pcf	0 psf	20.5°	3
Lean Clay	115 pcf	1000 psf	0°	2
Fat Clay	115 pcf	1000 psf	0°	7
Lean Clay (2)	115 pcf	1000 psf	0°	5
Silty Sand	125 pcf	0 psf	35°	4
Silty Sand (2)	125 pcf	0 psf	24.5°	6

Surface contour is depicted based on drawing called "East Ash Pond - USACE Levee" provided by TVA.
Depiction of soil profile between exploration holes is for illustration of possible geological continuity.
Actual conditions will most likely be different.

Piezometric lines are drawn based on field measurements of piezometric data at boring locations
and are assumed to be constant or a straight-line interpolation to extents of analysis where piezometric data is not available.

Factor of Safety: 1.014
Horizontal Seismic Coefficient: 0.185



Analysis performed by: MGD
Analysis checked by: MK

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Figure 3: Critical Failure Surface at Yield Acceleration for ALF East Ash Disposal Area

Tennessee Valley Authority
EPA Seismic Assessment
Project No. 20329
Oversight of Supplemental Site Exploration Program
Allen Fossil Plant - Memphis, TN

Geocomp CONSULTING, INC.

ALF Section B - Geocomp Soil Profile with Multiple Piezometric Lines - Post Quake
10/04/2012

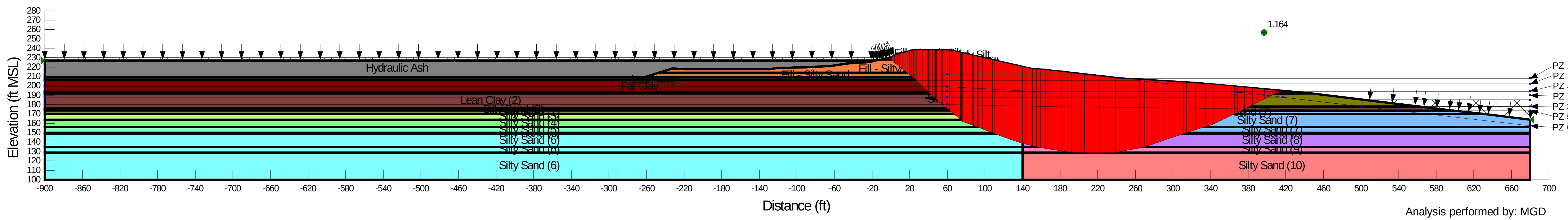
Material Properties

Material Type	Unit Weight	Cohesion	Friction Angle	PZ Line
Fill - Sandy Silt	125 pcf	0 psf	30	1
Fill - Silty Clay	125 pcf	2000 psf	---	1
Fill - Silty Sand	125 pcf	245 psf	---	1
Fill - Silty/Sandy Clay	125 pcf	1600 psf	---	1
Hydraulic Ash	105 pcf	c/p' = 0.06	---	1
Sandy Silt	125 pcf	225 psf	---	3
Lean Clay	115 pcf	1000 psf	---	2
Fat Clay	115 pcf	1000 psf	---	7
Lean Clay (2)	115 pcf	1000 psf	---	5
Silty Sand	125 pcf	0 psf	35	4
Silty Sand (2)	125 pcf	609 psf	---	6
Silty Sand (3)	125 pcf	693 psf	---	6
Silty Sand (4)	125 pcf	581 psf	---	6
Silty Sand (5)	125 pcf	672 psf	---	6
Silty Sand (6)	125 pcf	1052 psf + 6.5/ft	---	6
Silty Sand (7)	125 pcf	444 psf	---	6
Silty Sand (8)	125 pcf	658 psf	---	6
Silty Sand (9)	125 pcf	489 psf	---	6
Silty Sand (10)	125 pcf	810 psf + 6.5/ft	---	6

Surface contour is depicted based on drawing called "East Ash Pond - USACE Levee" provided by TVA.
Depiction of soil profile between exploration holes is for illustration of possible geological continuity.
Actual conditions will most likely be different.

Piezometric lines are drawn based on field measurements of piezometric data at boring locations
and are assumed to be constant or a straight-line interpolation to extents of analysis where piezometric data is not available.

Factor of Safety: 1.164



Analysis performed by: MGD
Analysis checked by: MK

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Figure 4: Critical Failure Surface for Post-Shaking Residual Shear Strength at ALF East Ash Disposal Area

Table 1: Factor of safety as a function of average horizontal acceleration coefficient

Tennessee Valley Authority
EPA Seismic Assessment
Project No. 20329
Oversight of Supplemental Site Exploration Program
Allen Fossil Plant - Memphis, TN
ALF - Section B

Geocomp CONSULTING, INC.

Strata	Static				Pseudo-Static				Post Quake - Idriss & Boulanger				Post Quake -Kramer			
	Unit Weight γ [pcf]	Cohesion [psf]	Undrained Shear Strength [psf]	Friction Angle ϕ [degrees]	Unit Weight γ [pcf]	Cohesion [psf]	Undrained Shear Strength [psf]	Friction Angle ϕ [degrees]	Unit Weight γ [pcf]	Cohesion [psf]	Undrained Shear Strength [psf]	Friction Angle ϕ [degrees]	Unit Weight γ [pcf]	Cohesion [psf]	Undrained Shear Strength [psf]	Friction Angle ϕ [degrees]
Fill - Sandy Silt	125	0	---	30	125	0	---	30	125	0	---	30	125	0	---	30
Fill - Silty Clay	125	---	2000	---	125	---	2000	---	125	---	2000	---	125	---	2000	---
Fill - Silty Sand	125	0	---	30	125	0	---	25	125	0	245	---	125	0	245	---
Fill - Silty/Sandy Clay	125	---	2000	---	125	---	1600	---	125	---	1600	---	125	---	1600	---
Hyrdaulic Ash	105	0	---	30	105	---	---	25	105	---	c / p' = 0.06	---	105	---	c / p' = 0.06	---
Sandy Silt	125	0	---	25	115	0	---	20.5	115	0	225	---	115	0	225	---
Lean Clay	115	---	1200	---	115	---	1000	---	115	---	1000	---	115	---	1000	---
Fat Clay	115	---	1200	---	115	---	1000	---	115	---	1000	---	115	---	1000	---
Lean Clay (2)	115	---	1200	---	115	---	1000	---	115	---	1000	---	115	---	1000	---
Silty Sand	125	0	---	35	125	0	---	35	125	0	---	35	125	0	---	35
Silty Sand (2)	125	0	---	30	125	0	---	24.5	125	0	620	---	125	0	609	---
Silty Sand (3)													125	---	693	---
Silty Sand (4)													125	---	581	---
Silty Sand (5)													125	---	672	---
Silty Sand (6)													125	---	1052+6.5 psf/ft	---
Silty Sand (7)													125	---	444	---
Silty Sand (8)													125	---	658	---
Silty Sand (9)													125	---	489	---
Silty Sand (10)													125	---	810+6.5 psf/ft	---

Global Stability Analysis Results

Horizontal Acceleration, K [g]		0.0	0.1	0.181	0.2	0.3	0.389	0.4	0.5	0.6
Static	Factor Of Safety	3.02	---	---	---	---	---	---	---	---
Pseudo-Static	Factor Of Safety	2.50	1.38	1.01	0.95	0.71	0.58	0.58	0.49	0.41
PQ - Idriss & Boulanger	Factor Of Safety	1.16	---	---	---	---	---	---	---	---

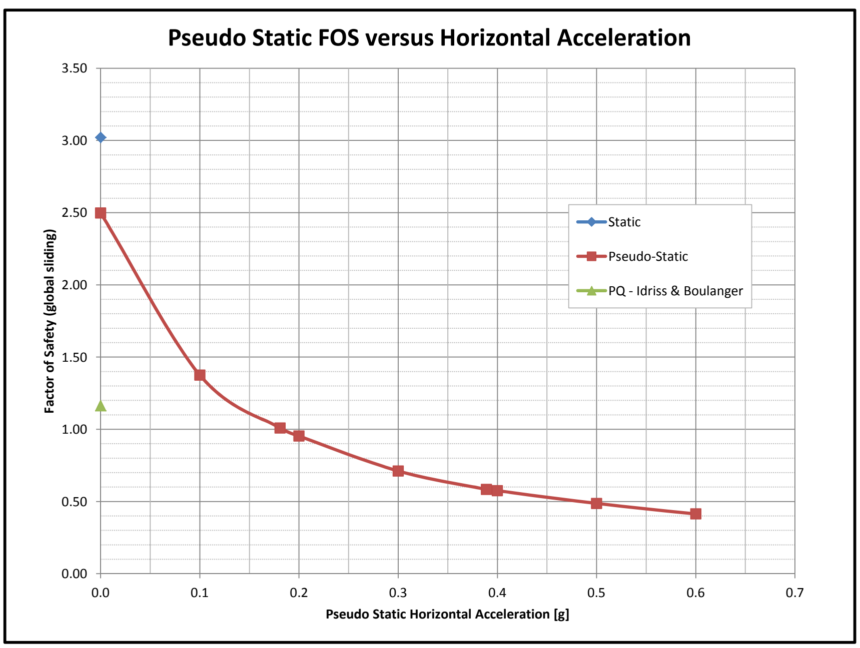


Table 2: Factor of safety against liquefaction and residual shear strengths (Borehole 2A)

Boring ALF-B-2A														
Depth (ft)						SPT			Liquefaction					
From	To	Elevation (ft)	Soil Type	Plastic / Non-Plastic	Fine Content (%)	Blow Counts (N)	$(N_1)_{60}$	$(N_1)_{60,cs}$	CRR	CSR	K_σ	CRR x K_σ	FOS	Post Shaking Strength (Idriss) (psf)
0	1	238.3	Fill - Sandy Silt	N/P	58.3	18	36.0	48.2	NL	0.341	1.00	NL	NL	74
1	2	237.3	Fill - Sandy Silt	N/P	58.3	18	36.0	48.2	NL		1.00	NL	NL	148
2	3	236.3	Fill - Sandy Silt	N/P	83.3	11	22.0	31.4	NL		1.00	NL	NL	119
3	4	235.3	Fill - Sandy Silt	N/P	83.3	11	22.0	31.4	NL	0.286	1.00	NL	NL	159
4	5	234.3	Fill - Sandy Silt	N/P	75.0	3	5.4	11.5	0.127	0.261	1.00	0.127	0.485	60
5	6	233.3	Fill - Sandy Silt	N/P	75.0	3	4.9	10.9	0.121	0.235	1.00	0.121	0.516	70
6	7	232.3	Fill - Silty Clay	P		6	9.2	NL	NL	0.210	1.00	NL	NL	NL
7	8	231.3	Fill - Silty Clay	P		6	8.6	NL	NL		1.00	NL	NL	NL
8	9	230.3	Fill - Silty Sand	N/P	83.3	13	17.6	26.1	NL		1.00	NL	NL	240
9	10	229.3	Fill - Silty Sand	N/P	83.3	13	16.7	25.0	NL	0.183	1.00	NL	NL	250
10	11	228.3	Fill - Silty Clay	P		13	15.9	NL	NL		1.00	NL	NL	NL
11	12	227.3	Fill - Silty Clay	P		13	15.2	NL	NL		1.00	NL	NL	NL
12	13	226.3	Fill - Silty Clay	P		2	2.2	NL	NL		1.00	NL	NL	NL
13	14	225.3	Fill - Silty Clay	P		2	2.2	NL	NL	0.171	1.00	NL	NL	NL
14	15	224.3	Fill - Silty Clay	P		7	7.3	NL	NL		1.00	NL	NL	NL
15	16	223.3	Fill - Silty Clay	P		7	7.1	NL	NL		1.00	NL	NL	NL
16	17	222.3	Fill - Silty Clay	P		6	5.9	NL	NL	0.168	0.99	NL	NL	NL
17	18	221.3	Fill - Silty Clay	P		6	5.7	NL	NL		0.97	NL	NL	NL
18	19	220.3	Fill - Clayey Silt	P		2	1.9	NL	NL		0.96	NL	NL	NL
19	20	219.3	Fill - Clayey Silt	P		2	1.8	NL	NL	0.166	0.94	NL	NL	NL
20	21	218.3	Fill - Silty Clay	P		4	3.5	NL	NL		0.93	NL	NL	NL
21	22	217.3	Fill - Silty Clay	P		4	3.4	NL	NL	0.164	0.91	NL	NL	NL
22	23	216.3	Fill - Silty Clay	P		5	4.2	NL	NL		0.90	NL	NL	NL
23	24	215.3	Fill - Silty Clay	P		5	4.1	NL	NL		0.89	NL	NL	NL
24	25	214.3	Fill – Silty Sand	N/P	83.3	3	2.4	7.9	0.095	0.163	0.88	0.084	0.514	237
25	26	213.3	Fill – Silty Sand	N/P	83.3	3	2.4	7.9	0.095	0.163	0.87	0.082	0.505	245
26	27	212.3	Fill – Silty Sand	N/P	83.0	3	2.3	7.8	0.094	0.163	0.86	0.081	0.499	253
27	28	211.3	Fill – Silty Sand	N/P	83.0	3	2.3	7.8	0.094	0.163	0.86	0.081	0.496	257
28	29	210.3	Fill – Silty Sand	N/P	83.0	1	0.8	5.9	0.079	0.161	0.85	0.067	0.417	227
29	30	209.3	Lean Clay	P		1	0.8	NL	NL	0.160	0.84	NL	NL	NL
30	31	208.3	Lean Clay	P		0	0.0	NL	NL	0.159	0.84	NL	NL	NL
31	32	207.3	Lean Clay	P		0	0.0	NL	NL	0.161	0.83	NL	NL	NL
32	33	206.3	Fat Clay	P				NL	NL	0.159	0.82	NL	NL	NL
33	34	205.3	Fat Clay	P				NL	NL		0.81	NL	NL	NL
34	35	204.3	Fat Clay	P		2	1.4	NL	NL		0.81	NL	NL	NL
35	36	203.3	Fat Clay	P		2	1.4	NL	NL	0.157	0.80	NL	NL	NL
36	37	202.3	Fat Clay	P		3	2.0	NL	NL		0.79	NL	NL	NL
37	38	201.3	Fat Clay	P		3	2.0	NL	NL		0.79	NL	NL	NL
38	39	200.3	Fat Clay	P				NL	NL		0.78	NL	NL	NL
39	40	199.3	Fat Clay	P				NL	NL	0.157	0.78	NL	NL	NL
40	41	198.3	Fat Clay	P				NL	NL		0.77	NL	NL	NL
41	42	197.3	Fat Clay	P				NL	NL		0.77	NL	NL	NL
42	43	196.3	Fat Clay	P		1	0.6	NL	NL	0.163	0.76	NL	NL	NL
43	44	195.3	Fat Clay	P		1	0.6	NL	NL		0.76	NL	NL	NL
44	45	194.3	Fat Clay	P		4	2.5	NL	NL		0.76	NL	NL	NL
45	46	193.3	Sandy Silt	N/P	8.3	4	2.5	2.9	0.058	0.169	0.75	0.043	0.257	272
46	47	192.3	Lean Clay	P		10	6.2	NL	NL	0.171	0.75	NL	NL	NL
47	48	191.3	Lean Clay	P		10	6.1	NL	NL		0.74	NL	NL	NL
48	49	190.3	Lean Clay	P		7	4.2	NL	NL	0.162	0.74	NL	NL	NL
49	50	189.3	Lean Clay	P		7	4.2	NL	NL		0.74	NL	NL	NL
50	51	188.3	Silty Sand	N/P	8.3	9	5.4	5.8	0.078	0.157	0.73	0.058	0.366	395
51	52	187.3	Silty Sand	N/P	8.3	9	5.4	5.8	0.078	0.161	0.73	0.057	0.356	398
52	53	186.3	Silty Sand	N/P	33.3	6	3.6	9.1	0.105	0.164	0.73	0.077	0.468	409
53	54	185.3	Silty Sand	N/P	33.3	6	3.5	9.1	0.105	0.166	0.73	0.077	0.461	412
54	55	184.3	Lean Clay	P		4	2.3	NL	NL	0.168	0.72	NL	NL	NL
55	56	183.3	Lean Clay	P		4	2.3	NL	NL		0.72	NL	NL	NL
56	57	182.3	Lean Clay	P		6	3.4	NL	NL		0.72	NL	NL	NL
57	58	181.3	Lean Clay	P		6	3.4	NL	NL		0.71	NL	NL	NL
58	59	180.3	Lean Clay	P		2	1.1	NL	NL	0.159	0.71	NL	NL	NL
59	60	179.3	Lean Clay	P		2	1.1	NL	NL		0.71	NL	NL	NL
60	61	178.3	Lean Clay	P				NL	NL		0.70	NL	NL	NL
61	62	177.3	Lean Clay	P				NL	NL		0.69	NL	NL	NL
62	63	176.3	Silty Sand	N/P	41.7	9	4.8	10.8	0.120	0.152	0.69	0.082	0.540	561
63	64	175.3	Silty Sand	N/P	41.7	9	4.8	10.7	0.120	0.154	0.68	0.082	0.532	565
64	65	174.3	Silty Sand	N/P	8.3	17	9.0	9.5	0.109	0.155	0.68	0.074	0.477	678
65	66	173.3	Silty Sand	N/P	8.3	17	9.0	9.5	0.108	0.157	0.68	0.074	0.470	682
66	67	172.3	Silty Sand	N/P	8.3	13	6.8	7.3	0.090	0.159	0.68	0.061	0.384	582
67	68	171.3	Silty Sand	N/P	8.3	13	6.8	7.3	0.090	0.161	0.68	0.061	0.377	585
68	69	170.3	Silty Sand	N/P	8.3	17	8.8	9.3	0.107	0.161	0.68	0.073	0.450	693
69	70	169.3	Silty Sand	N/P	8.3	17	8.8	9.3	0.107	0.162	0.67	0.072	0.447	697
70	71	168.3	Silty Sand	N/P	33.3	15	7.7	14.1	0.151	0.162	0.67	0.101	0.627	752
71	72	167.3	Silty Sand	N/P	33.3	15	7.7	14.0	0.150	0.161	0.67	0.101	0.625	756
72	73	166.3	Silty Sand	N/P	8.3	14	7.2	7.6	0.093	0.161	0.67	0.062	0.385	628
73	74	165.3	Silty Sand	N/P	8.3	14	7.1	7.6	0.093	0.161	0.67	0.062	0.384	632
74	75	164.3	Silty Sand	N/P	8.3	12	6.1	6.6	0.084	0.162	0.67	0.056	0.345	583
75	76	163.3	Silty Sand	N/P	8.3	12	6.1	6.5	0.084	0.163	0.66	0.056	0.342	586
76	77	162.3	Silty Sand	N/P	8.3	11	5.5	6.0	0.080	0.164	0.66	0.053	0.322	563
77	78	161.3	Silty Sand	N/P	8.3	11	5.5	6.0	0.079	0.165	0.66	0.053	0.319	567
78	79	160.3	Silty Sand	N/P	8.3	13	6.5	7.0	0.087	0.166	0.66	0.058	0.348	622
79	80	159.3	Silty Sand	N/P	8.3	13	6.5	6.9	0.087	0.165	0.66	0.057	0.347	626
80	81	158.3	Silty Sand	N/P	8.3	10	5.0	5.4	0.075	0.165	0.66	0.049	0.299	550
81	82	157.3	Silty Sand	N/P	8.3	10	4.9	5.4	0.075	0.163	0.66	0.049	0.302	553
82	83	156.3	Silty Sand	N/P	16.7	14	6.9	10.2	0.115	0.160	0.65	0.075	0.471	663
83	84	155.3	Silty Sand	N/P	16.7	14	6.9	10.2	0.115	0.158	0.65	0.075	0.475	666
84	85	154.3	Silty Sand	N/P	25.0	12	5.9	10.8	0.121	0.156	0.65	0.079	0.505	671
85	86	153.3	Silty Sand	N/P	25.0	12	5.9	10.8	0.120	0.153	0.65	0.078	0.510	675
86	87	152.3	Silty Sand	N/P	8.3	14	6.8	7.3	0.090	0.151	0.65	0.058	0.386	677
87	88	151.3	Silty Sand	N/P	8.3	14	6.8	7.2	0.090	0.149	0.65	0.058	0.390	680
88	89	150.3	Silty Sand	N/P	25.0	15	7.2	12.4	0.135	0.149	0.65	0.087	0.584	770
89	90	149.3	Silty Sand	N/P	25.0	15	7.2	12.3	0.134	0.150	0.64	0.087	0.576	774
90	91	148.3	Silty Sand	N/P	16.7	14	6.7	10.0	0.114	0.150	0.64	0.073	0.486	690
91	92	147.3	Silty Sand	N/P	16.7	14	6.7	10.0	0.113	0.150	0.64	0.073	0.484	694
92	93	146.3	Silty Sand	N/P	8.3	15	7.1	7.6	0.093	0.151	0.64	0.059	0.394	725
93	94	145.3	Silty Sand	N/P	8.3	15	7.1	7.6	0.092	0.151	0.64	0.059	0.393	729
94	95	144.3	Silty Sand	N/P	16.7	16	7.6	10.9	0.122	0.151	0.64	0.078	0.515	761
95	96	143.3	Silty Sand	N/P	16.7	16	7.5	10.9	0.121	0.151	0.64	0.077	0.513	764

Table 3: Factor of safety against liquefaction and residual shear strengths (Borehole 2B)

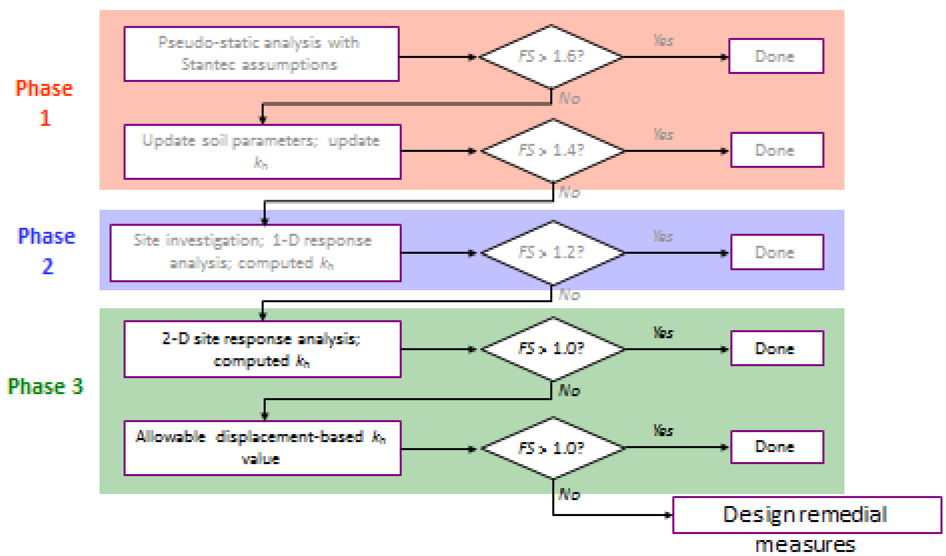
Boring ALF-B-2B														
Depth (ft)						SPT			Liquefaction					
From	To	Elevation	Soil Type	Plastic / Non-Plastic	Fine Content (%)	Blow Counts (N)	$(N_1)_{60}$	$(N_1)_{60,cs}$	CRR	CSR	K_σ	CRR x K_σ	FOS	Post Shaking Strength (Idriss) (psf)
0	1	217.5	Fill - Silty Sand	N/P	33	8	16	23.8	0.270	0.555	1.00	0.270	0.487	20
1	2	216.5	Fill - Silty Sand	N/P	33	8	16	23.8	0.270	0.527	1.00	0.270	0.512	41
2	3	215.5	Fill - Sandy Clay	P		8	16	NL	NL	0.500	1.00	NL	NL	NL
3	4	214.5	Fill - Sandy Clay	P		8	16	NL	NL	0.472	1.00	NL	NL	NL
4	5	213.5	Fill - Sandy Clay	P		2	4	NL	NL	0.444	1.00	NL	NL	NL
5	6	212.5	Fill - Sandy Clay	P		2	3	NL	NL		1.00	NL	NL	NL
6	7	211.5	Fill - Sandy Clay	P		3	5	NL	NL		1.00	NL	NL	NL
7	8	210.5	Fill - Sandy Clay	P		3	4	NL	NL	0.342	1.00	NL	NL	NL
8	9	209.5	Fill - Sandy Clay	P		1	1	NL	NL	0.353	1.00	NL	NL	NL
9	10	208.5	Fill - Sandy Clay	P		1	1	NL	NL		1.00	NL	NL	NL
10	11	207.5	Lean Clay	P		2	2	NL	NL	0.304	1.00	NL	NL	NL
11	12	206.5	Lean Clay	P		2	2	NL	NL	0.247	1.00	NL	NL	NL
12	13	205.5	Lean Clay	P		1	1	NL	NL		1.00	NL	NL	NL
13	14	204.5	Lean Clay	P		1	1	NL	NL	0.248	1.00	NL	NL	NL
14	15	203.5	Lean Clay	P		3	3	NL	NL		1.00	NL	NL	NL
15	16	202.5	Fat Clay	P		3	3	NL	NL	0.236	1.00	NL	NL	NL
16	17	201.5	Fat Clay	P		2	2	NL	NL		1.00	NL	NL	NL
17	18	200.5	Fat Clay	P		2	2	NL	NL		0.99	NL	NL	NL
18	19	199.5	Fat Clay	P				NL	NL	0.219	0.98	NL	NL	NL
19	20	198.5	Fat Clay	P				NL	NL		0.96	NL	NL	NL
20	21	197.5	Fat Clay	P		1	1	NL	NL		0.95	NL	NL	NL
21	22	196.5	Fat Clay	P		1	1	NL	NL	0.220	0.94	NL	NL	NL
22	23	195.5	Fat Clay	P		2	2	NL	NL		0.93	NL	NL	NL
23	24	194.5	Fat Clay	P		2	2	NL	NL		0.91	NL	NL	NL
24	25	193.5	Fat Clay	P		1	1	NL	NL	0.224	0.90	NL	NL	NL
25	26	192.5	Fat Clay	P		1	1	NL	NL		0.89	NL	NL	NL
26	27	191.5	Fat Clay	P		6	5	NL	NL		0.88	NL	NL	NL
27	28	190.5	Sandy Silt	N/P	67	6	5	10.8	0.120	0.214	0.87	0.105	0.489	292
28	29	189.5	Sandy Silt	N/P	67	2	2	6.9	0.087	0.213	0.87	0.075	0.353	233
29	30	188.5	Sandy Silt	N/P	67	2	2	6.9	0.086	0.211	0.86	0.074	0.351	240
30	31	187.5	Sandy Silt	N/P	67	2	2	6.8	0.086	0.209	0.85	0.073	0.349	248
31	32	186.5	Sandy Silt	N/P	67	2	1	6.8	0.086	0.208	0.84	0.072	0.348	255
32	33	185.5	Sandy Silt	N/P	67	5	4	9.4	0.108	0.206	0.83	0.090	0.436	
33	34	184.5	Sandy Silt	N/P	50	5	4	9.3	0.107	0.204	0.82	0.089	0.434	
34	35	183.5	Sandy Silt	N/P	50	3	2	7.6	0.092	0.202	0.82	0.075	0.373	271
35	36	182.5	Sandy Silt	N/P	50	3	2	7.5	0.092	0.200	0.81	0.075	0.373	278
36	37	181.5	Sandy Silt	N/P	16.67	5	3	6.6	0.084	0.198	0.80	0.068	0.343	243
37	38	180.5	Sandy Silt	N/P	16.67	5	3	6.6	0.084	0.196	0.80	0.067	0.342	249
38	39	179.5	Sandy Silt	N/P	16.67	2	1	4.4	0.067	0.194	0.79	0.053	0.275	202
39	40	178.5	Lean Clay	P		2	1	NL	NL	0.192	0.78	NL	NL	NL
40	41	177.5	Lean Clay	P		0	0	NL	NL	0.184	0.78	NL	NL	NL
41	42	176.5	Lean Clay	P		0	0	NL	NL	0.177	0.77	NL	NL	NL
42	43	175.5	Lean Clay	P				NL	NL	0.182	0.77	NL	NL	NL
43	44	174.5	Silty Sand	N/P	42				0.049	0.187	0.77	0.038	0.201	
44	45	173.5	Silty Sand	N/P	42	14	9	15.7	0.167	0.187	0.76	0.128	0.682	535
45	46	172.5	Silty Sand	N/P	42	14	9	15.6	0.167	0.192	0.76	0.127	0.659	540
46	47	171.5	Silty Sand	N/P	42	10	6	12.6	0.136	0.198	0.76	0.103	0.523	454
47	48	170.5	Silty Sand	N/P	42	10	6	12.5	0.136	0.197	0.76	0.103	0.521	458
48	49	169.5	Silty Sand	N/P	42	15	9	16.2	0.172	0.197	0.75	0.130	0.660	577
49	50	168.5	Silty Sand	N/P	42	15	9	16.1	0.172	0.197	0.75	0.129	0.655	582
50	51	167.5	Silty Sand	N/P	42	10	6	12.4	0.135	0.196	0.75	0.101	0.514	471
51	52	166.5	Silty Sand	N/P	42	10	6	12.3	0.134	0.196	0.74	0.100	0.511	475
52	53	165.5	Silty Sand	N/P	42	15	9	16.0	0.170	0.195	0.74	0.126	0.645	596
53	54	164.5	Silty Sand	N/P	8	15	9	9.5	0.109	0.195	0.74	0.080	0.412	522
54	55	163.5	Silty Sand	N/P	8	8	5	5.3	0.074	0.195	0.74	0.055	0.280	370
55	56	162.5	Silty Sand	N/P	0	8	5	4.8	0.071	0.194	0.74	0.052	0.267	338
56	57	161.5	Silty Sand	N/P	0	7	4	4.2	0.066	0.194	0.73	0.048	0.249	320
57	58	160.5	Silty Sand	N/P	0	7	4	4.1	0.066	0.194	0.73	0.048	0.248	323
58	59	159.5	Silty Sand	N/P	8	11	6	6.9	0.087	0.189	0.73	0.064	0.337	448
59	60	158.5	Silty Sand	N/P	8	11	6	6.9	0.087	0.183	0.73	0.063	0.345	451
60	61	157.5	Silty Sand	N/P	0	14	8	8.2	0.097	0.178	0.72	0.070	0.396	484
61	62	156.5	Silty Sand	N/P	0	14	8	8.1	0.097	0.173	0.72	0.070	0.405	488
62	63	155.5	Silty Sand	N/P	0	10	6	5.8	0.078	0.167	0.72	0.056	0.335	400
63	64	154.5	Silty Sand	N/P	0	10	6	5.7	0.078	0.162	0.72	0.056	0.344	403
64	65	153.5	Silty Sand	N/P	17	13	7	10.8	0.120	0.162	0.71	0.086	0.530	515
65	66	152.5	Silty Sand	N/P	17	13	7	10.8	0.120	0.163	0.71	0.085	0.526	519
66	67	151.5	Silty Sand	N/P	17	14	8	11.3	0.125	0.163	0.71	0.089	0.546	546
67	68	150.5	Silty Sand	N/P	17	14	8	11.3	0.125	0.163	0.71	0.088	0.543	550
68	69	149.5	Silty Sand	N/P	8	20	11	11.7	0.129	0.163	0.71	0.091	0.560	706
69	70	148.5	Silty Sand	N/P	8	20	11	11.7	0.128	0.163	0.70	0.090	0.556	710
70	71	147.5	Silty Sand	N/P	17	14	8	11.2	0.124	0.163	0.70	0.087	0.533	561
71	72	146.5	Silty Sand	N/P	17	14	8	11.1	0.123	0.163	0.70	0.086	0.530	564
72	73	145.5	Silty Sand	N/P	8	18	10	10.4	0.117	0.163	0.70	0.082	0.502	669
73	74	144.5	Silty Sand	N/P	8	18	10	10.4	0.116	0.163	0.70	0.081	0.499	673
74	75	143.5	Silty Sand	N/P	8	13	7	7.6	0.092	0.163	0.70	0.064	0.394	550
75	76	142.5	Silty Sand	N/P	8	13	7	7.5	0.092	0.163	0.69	0.064	0.392	554
76	77	141.5	Silty Sand	N/P	8	21	11	11.9	0.130	0.163	0.69	0.090	0.553	766
77	78	140.5	Silty Sand	N/P	8	21	11	11.8	0.130	0.163	0.69	0.089	0.550	770
78	79	139.5	Silty Sand	N/P	17	20	11	14.3	0.153	0.162	0.69	0.105	0.647	747
79	80	138.5	Silty Sand	N/P	17	20	11	14.2	0.152	0.162	0.69	0.105	0.644	751
80	81	137.5	Silty Sand	N/P	8	14	7	7.9	0.095	0.162	0.68	0.065	0.402	596
81	82	136.5	Silty Sand	N/P	8	14	7	7.9	0.095	0.162	0.68	0.065	0.400	600
82	83	135.5	Silty Sand	N/P	0	13	7	6.9	0.086	0.162	0.68	0.059	0.363	530
83	84	134.5	Silty Sand	N/P	0	13	7	6.8	0.086	0.162	0.68	0.059	0.362	533
84	85	133.5	Silty Sand	N/P	0	9	5	4.7	0.070	0.162	0.68	0.047	0.292	439
85	86	132.5	Silty Sand	N/P	0	9	5	4.7	0.070	0.162	0.68	0.047	0.292	442
86	87	131.5	Silty Sand	N/P	0	11	6	5.7	0.077	0.162	0.67	0.052	0.322	493
87	88	130.5	Silty Sand	N/P	0	11	6	5.7	0.077	0.162	0.67	0.052	0.321	496
88	89	129.5	Silty Sand	N/P	33	26	13	20.7	0.224	0.161	0.67	0.151	0.935	1094
89	90	128.5	Silty Sand	N/P	33	26	13	20.6	0.224	0.161	0.67	0.150	0.929	1099
90	91	127.5	Silty Sand	N/P	8	18	9	9.7	0.110	0.161	0.67	0.074	0.458	739
91	92	126.5	Silty Sand	N/P	8	18	9	9.7	0.110	0.161	0.67	0.073	0.455	743
92	93	125.5	Silty Sand	N/P	0	20	10	10.1	0.114	0.161	0.66	0.076	0.473	748
93	94	124.5	Silty Sand	N/P	0	20	10	10.1	0.114	0.160	0.66	0.076	0.471	751
94	95	123.5	Silty Sand	N/P	0	20	10	10.1	0.114	0.160	0.66	0.075	0.470	755
95	96	122.5	Silty Sand	N/P	0	20	10	10.0	0.113	0.160	0.66	0.075	0.467	758

Appendix 1

Approach to Evaluation for Earthquake Loading

Table A-1: Approach to Assessing Performance Under Earthquake Loading

Technical Approach:



Technical Approach:

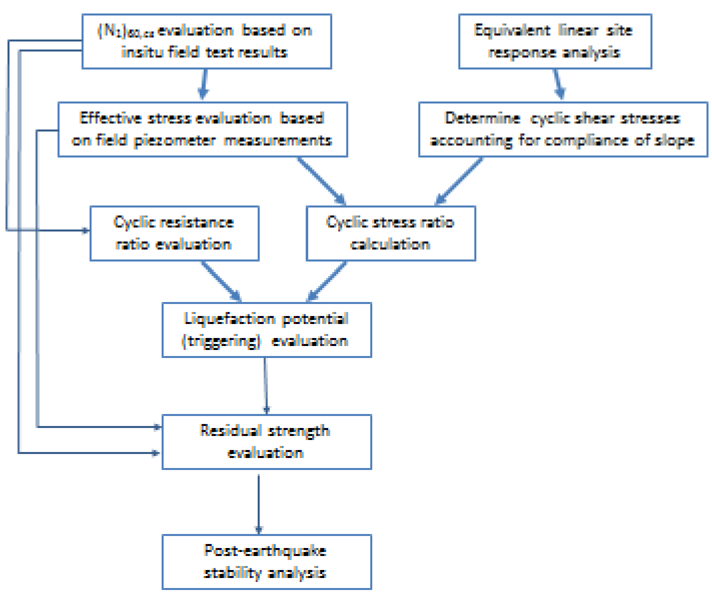


Table A-2: Procedure to Determine Shear Strength of Soil

Soil Material Type	Static Strength	Pseudo Static Strength	Residual Strength
Unsaturated non-plastic soils	$c'=0$; $\phi' = \{[15.4(N_1)_{60}]^{0.5} + 20\}$	100% of Static Strength	100% of Static Strength
Saturated non-plastic soils	$c'=0$; $\phi' = \{[15.4(N_1)_{60}]^{0.5} + 20\}$	80% of Static Strength	Idriss and Boulanger (2007)
Unsaturated plastic soils	Undrained Shear Strength from tests	100% of Static Strength	100% of Static Strength
Saturated plastic soils	Undrained Shear Strength from tests	80% of Static Strength	80% of Static Strength
Fly ash (sluiced)	$c'=0$; $\phi' = 30°$	$c'=0$; $\phi' = 25°$	$s_u/\sigma'_{vc} = 0.06$

$$(N_1)_{60} = N_{60} * \left(\frac{P_a}{\sigma'_v}\right)^{0.5} \quad \text{correction to not exceed 2.0}$$

S_u from interpretation of lab and field tests

- DSS – Direct Simple Shear
- $0.22p_c'$ - p_c' is preconsolidation test measured in one-dimensional consolidation test
- Triaxial Compression*0.64 – consolidated undrained triaxial strength converted to DSS
- $(q_c - \sigma_v)/15$ - cone penetration resistance converted to undrained shear strength
- s_u psf $= 0.085*V_s^{1.6}$ V_s in ft/sec – shear wave velocity converted to undrained shear strength,
- s_u psf $= 125 * N_{60}$ – uncorrected blow count converted to undrained shear strength

Tennessee Valley Authority, 1101 Market Street, BR4A, Chattanooga, Tennessee 37402

October 19, 2012

Mr. Stephen Hoffman
US Environmental Protection Agency (EPA) (5304P)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

TENNESSEE VALLEY AUTHORITY (TVA) – COMMENTS ON COAL ASH SITE ASSESSMENT ROUND 11 DRAFT REPORTS FOR ALLEN (ALF), BULL RUN, (BRF) COLBERT (COF), CUMBERLAND (CUF), GALLATIN (GAF), JOHN SEVIER (JSF), JOHNSONVILLE, (JOF) KINGSTON (KIF), PARADISE (PAF), SHAWNEE (SHF), WATTS BAR (WBF), AND WIDOWS CREEK (WOF) FOSSIL PLANTS

Dear Mr. Hoffman:

Tennessee Valley Authority (TVA) appreciates the opportunity to provide responses to the recommendations outlined in the Draft Coal Ash Site Assessment Round 11 Draft Reports for TVA's fossil plants. The Draft Reports were attached to EPA's September 5, 2012 email from Jana Englander to TVA's Susan Kelly. This EPA review process has provided TVA a public forum to confirm that our coal ash facilities meet current state requirements.

TVA has contracted with Stantec Consulting Services Inc., to assist in the technical review and responses to the EPA draft reports. The draft report responses are attached for your consideration in finalizing the Coal Ash Site Assessment Round 11 Reports. The following is a summary of our responses;

Allen: A seismic stability analysis and liquefaction analysis have been completed indicating acceptable performance under seismic loading. TVA recommends the Allen East Ash Pond be upgraded from Poor to Satisfactory.

Bull Run: TVA has no additional comments to EPA's analysis.

Colbert: TVA has no additional comments to EPA's analysis.

Cumberland: The operating pool level for the Ash Pond has been lowered 6.2 feet and the seepage analysis has been revised. Piping factors of safety are now satisfactory. TVA recommends the final rating for the Ash Pond be upgraded from Fair to Satisfactory.

A liquefaction potential assessment was performed for the Gypsum Disposal Area and showed the saturated ash materials are anticipated to undergo liquefaction for the 2,500-year earthquake. Therefore, a higher level of slope stability analysis was completed demonstrating that the factor of safety is satisfactory. TVA recommends the final rating for the Gypsum Disposal Area be upgraded from Poor to Satisfactory.

Additional seismic analysis and field investigation is underway for the Dry Fly Ash Stack. The results are indicating the possibility of a favorable response. However, the analysis is not complete. We anticipate its completion during EPA's review of these comments.

Gallatin: A seismic stability analysis for Ponds A and E has been completed with acceptable results. TVA recommends the final rating be upgraded from Fair to Satisfactory.

An additional stability and seepage analysis for the saddle dikes on the stilling ponds has been completed and a project to increase the hydrologic/hydraulic capacity of the ponds is underway. Based on the analysis and improvement plans underway, TVA recommends the Gallatin Stilling Ponds rating be upgraded from Poor to Fair and from Fair to Satisfactory once the project is completed.

John Sevier: The static and seismic slope stability analysis were reviewed and deemed to be appropriate for the soil materials present.

Johnsonville: A quantitative liquefaction analysis and a post-earthquake static slope stability analysis were performed. Results showed the slope to remain stable. As a result, TVA recommends that final rating for Ash Disposal Area 2 be upgraded from Fair to Satisfactory.

Kingston: TVA has no additional comments to EPA's analysis.

Paradise: A liquefaction analysis was performed and the hydrologic/hydraulic capacity was evaluated. The liquefaction analysis indicated that the materials would remain stable and not liquefy during a 2,500 year event. The H&H analysis confirmed that the ponds safely pass the 100-year 24-hour storm. However, they do not pass the Probable Maximum Flood. TVA has plans to design and construct features to correct this issue at the ponds. TVA recommends that the facilities at Paradise be upgraded from Fair to Satisfactory once the H&H issues have been addressed.

Shawnee: A liquefaction analysis and post-earthquake static stability analysis were performed with acceptable results. TVA recommends that the rating for Ash Pond No. 2 be upgraded from Poor to Satisfactory.

Watts Bar: A hydrologic/hydraulic analysis was performed for the design storm and the new spillway system currently under design and in construction. Based on the satisfactory outcome of the analysis; TVA recommends the final rating be upgraded from Fair to Satisfactory.

Widows Creek: TVA has no additional comments to EPA's analysis.

The following is a summary of the draft facility ratings and TVA's proposed final ratings.

EPA Draft Report Results

Plant	Facility	Draft Rating	Driver for Rating	Stantec Proposed Final Rating
ALF	East Pond	Poor	Seismic	Sat
BRF	FA Pond	Sat		Sat
	BA Pond	Fair	Liquefaction	Fair
	Gyp Pond	Fair	Liquefaction	Fair
COF	Dry Stack	Sat		Sat
	BA Pond	Fair	Liquefaction	Fair
CUF	Ash Pond	Fair	Piping	Sat
	Dry Stack	Poor	Seismic	Poor
	Gyp	Poor	Seismic	Sat
GAF	Ash Ponds	Fair	Liquefaction	Sat
	Stilling Ponds	Poor	H&H and static	Fair
JSF	Dry Stack	Sat		Sat
	Ash pond	Sat		Sat
JOF	Island	Fair	Liquefaction	Sat
KIF	Ash/stilling	Fair	Liquefaction	Fair
	GDA	Sat		Sat
PAF	Scrubber sludge	Fair	H&H - overtopping	Fair
	Ash Pond	Fair	H&H - overtopping	Fair
	Slag Ponds	Fair	H&H - overtopping	Fair
SHF	Ash Pond	Poor	Seismic	Sat
WBF	Pond	Fair	H&H	Sat
WCF	Gyp stack	Sat		Sat
	Ash Pond	Fair	Liquefaction	Fair

TVA takes its environmental responsibilities very seriously and appreciates EPA's efforts to verify the quality of our impoundments. We would like to arrange a conference call once your staff has received this letter and briefly reviewed the attached reports so we can answer any immediate questions or concerns. Please contact Susan Kelly at (423)-751-2058 or sjkelly0@tva.gov to arrange this conference call.

Sincerely,

Cynthia M. Anderson
for

Brenda E. Brickhouse
Vice President
Compliance Interface and Permits

Enclosures

SJK:LMB
Enclosures
cc (electronic distribution with enclosures):

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